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(71) Applicant *(for all designated States except US)*: CORAL S.P.A. [IT/IT]; Strada Volpiano, 52, I-10040 Leinì (IT).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: CORAL, Nevio [IT/IT]; Strada Volpiano, 60, I-10040 Leinì (IT). CORAL, Luciano [IT/IT]; Via Valletta, 45, I-10040 Leinì (IT). CORAL, Claudio [IT/IT]; Strada Volpiano, 60, I-10040 Leinì (IT).

(74) Agents: JORIO, Paolo et al.; Studio Torta, Via Viotti, 9, I-10121 Torino (IT).

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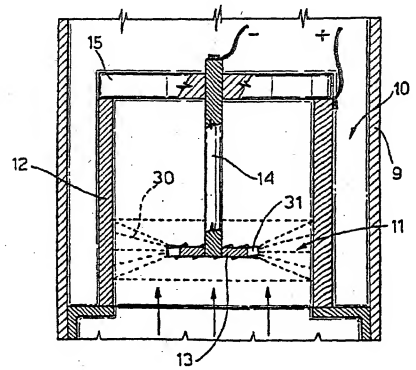
(57) Abstract

The method includes a step of creating a flow of the mixture, a step of generating an electron discharge at a velocity such as to create a zone in which the mixture is ionised and a step of directing a series of electron beams so as to intercept the flow of the mixture whereby the peripheral electron bonds of the polluting molecules and/or cells are broken by collision with the ions formed in the mixture. The apparatus includes an ionisation cell (10) having an anode (12) and an emitting cathode (13) excited at a negative voltage of the order of 50,000 volts. The cathode (13) has a series of pointed elements for emitting electron beams (30) which intersect in a zone (11) of interception of the mixture.



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A METHOD AND APPARATUS FOR PURIFYING A GASEOUS MIXTURE INCLUDING MOLECULES AND/OR CELLS OF TOXIC OR POLLUTING SUBSTANCES

TECHNICAL FIELD

The present invention relates to a method and apparatus for purifying a gaseous mixture including molecules and/or cells of toxic or polluting substances.

BACKGROUND ART

Various types of apparatus for purifying gases to break down or neutralise the polluting substances are known. In one known type, also used in catalytic converters for the exhaust gases from internal combustion engines a thermal reactor is used in which the mass of the reactor is brought to a high temperature to achieve complete oxidation and/or thermal dissociation of the molecules of the polluting substances. For this operation it is first necessary to reduce the velocity of the gas flow drastically by passing it through a series of chambers or into a highly obstructive catalytic path.

This apparatus is in general very expensive both because of the energy required in operation and because of the equipment required for regulating and controlling it. Moreover it cannot be used when the gases to be purified contain molecules of heavy metals, chlorinated hydrocarbons, phosphorus, arsenic, boron, lead, zinc and like toxic substances.

Finally even for the substances for which this apparatus is effective, large quantities of carbon dioxide are released which is known to stratify at relatively low contents. A barrier or greenhouse is thus formed which means that heat accumulates causing harmful variations in local climate, for example in large cities.

Apparatus is also known for purifying gas by means of chemical reactions in which the pollutant is transferred to liquid or solid reagents. When these reagents become saturated or exhausted, however, they become corrosive and/or caustic whereby it is not easy to dispose of them ecologically.

Finally, purifying apparatus is known which is based on the reaction of molecules in a gas with molecules on the surface of a solid material, known as adsorption. In this, the gas is retained by the surfaces of grains of adsorbent material, for example activated carbon, in a so-called adsorption reactor. These reactors, however, have the disadvantage that the surfaces of the grains rapidly become clogged so that they have to be regenerated frequently. Hence, in general, this type of apparatus may be used solely with gases having low concentrations of substances to be removed. Moreover, in a plant which operates in a continuous cycle, the apparatus must be duplicated so that there is always one unit working while the other is being regenerated.

DISCLOSURE OF INVENTION

The object of the invention is to provide a method and apparatus for purifying gaseous mixtures which is extremely simple and reliable in operation and eliminates the problems of the prior art listed above.

This object is achieved by the purification method of the invention which includes a step of passing a flow of the gaseous mixture along a path and is characterised in that an electron discharge is generated in the path, the electrons travelling at velocities such as to create a zone of ionisation of the mixture, and a series of electron beams is directed so as to intercept the flow whereby the peripheral electron bonds of the molecules and/or cells of the said substances are broken by collision with the electrons.

The corresponding apparatus is arranged in a path along which the mixture is conveyed and is characterised in that it includes an ionisation cell for creating a discharge of electrons at velocities such as to create an ionisation zone which intercepts the mixture, breaking the peripheral electron bonds of the molecules and/or cells of the said substances.

BRIEF DESCRIPTION OF DRAWINGS

For a better understanding of the invention, a preferred embodiment will be described below purely by way of example, with the aid of the appended drawings, in which:

Figure 1 is a schematic drawing of a complex

molecule of a polluting substance;

Figure 2 is a schematic section of a gas duct of apparatus for carrying out the purifying method of the invention;

Figure 3 is a plan view of a detail of the apparatus according to a variant of Figure 2, on an enlarged scale;

Figure 4 is a side view of the detail of Figure 3;

Figure 5 is an electronic circuit diagram for the supply of the apparatus of Figure 2.

BEST MODE FOR CARRYING OUT THE INVENTION

Atmospheric pollution in general, and of closed environments in particular, results from the mixture of air with gaseous components, which are often noisome, and suspensions of dust of various types, for example pollens, which cause allergies, or bacteria or the like. All these substances may also be toxic or noxious when breathed in by living beings

More particularly, in industrial plants, for example chemical plants, the usual chimneys convey a gaseous mixture into the atmosphere which is generally termed simply 'gas' but which carries high concentrations of molecules of one or more of the following substances mixed or suspended therein: heavy metals, lead, zinc, boron, cement, arsenic, phosphorus, chlorinated hydrocarbons derived from plastics materials, and other substances.

In addition combustion plants in general and internal combustion engines in particular discharge gases into the atmosphere which contain one or more of the following substances: powdered carbon and sulphur, unburnt hydrocarbons, carbon monoxide, oxides of nitrogen, carbon dioxide and oxides of sulphur, sulphides, benzene, etc.

Moreover in closed animal breeding and plant cultivation environments, the air is polluted by molecules of noisome substances and/or pollens. Finally enclosed environments for public use, for example convention and entertainment halls, as well as in hospitals and nursing homes, the air is vitiated or polluted by carbon dioxide and various exhalations and bacteria or the like.

The molecules of such organic and inorganic pollutants are generally complex, that is, formed from several simple molecules. By way of example, Figure 1 shows a complex pollutant molecule 5 which is constituted by a number of simple molecules 6 and 7 held together by bonds formed by negative electrons 8 moving in orbits outside the nucleus of the individual molecules. These electrons, due to their high velocities, acquire centrifugal forces away from the nuclei which are, in general, balanced by the centripetal attractive forces of the positive ions of the nuclei, whereby the molecules are neutral.

Biological pollutants are, in their turn, generally constituted by cells or groups of cells which, in certain conditions, tend to reproduce and to influence the cells of other organisms.

It is known from physics that, if a suitable negative electric voltage is applied to a cathode immersed in a gas, the negative electrons concentrate on its surface. When a predetermined voltage is exceeded, these electrons are expelled and travel at high velocities towards the anode. These electrons, in impinging upon particles of gas or dust (molecules or cells), create other ions whereby the whole gaseous mixture rapidly becomes ionised. If the surface of the cathode has an edge, a projection or a pointed element, the electrons accumulate and are emitted continuously from the edge, projection or pointed element.

With reference to Figure 2, an exhaust duct is generally indicated 9 which is arranged to convey the gas towards the exterior. Purification apparatus is arranged in the duct 9 and includes a cell generally indicated 10 in which an electron discharge is generated, the electrons travelling at velocities such as to create a zone 11 of ionisation of the gas. More particularly, the cell 10 includes a cylindrical anode 12 of conductive material, for example aluminium, or preferably stainless steel to avoid the problems of oxidation.

Within the anode 12 is a cathode 13 for emitting negative ions which is constituted by a circular disc of conductive material fixed to a shank 14 which is connected to a bar 15 of non-conductive material. The bar 15 is in turn fixed to the upper edge of the anode 12. The disc 13 carries a series of metal filiform elements 31, for example like those of a metal brush. Alternatively the disc 13 may have a series of triangular teeth.

In the variant shown in Figures 3 and 4, the disc 13 is of sheet metal of a predetermined thickness and has a peripheral edge 16 formed with a set of V-shaped notches 17 at predetermined mutual spacings. The notches 17 are separated by teeth 18 each of which is bent into a helical shape about a radial axis relative to the disc 13 whereby the outer edge 16 of each tooth is disposed in a helix.

The voltage supplied to the purification cell 10 is generated by an electronic circuit, generally indicated 19, which includes a transformer 20 for reducing the mains voltage and a current rectifier 21 which rectifies the mains alternating current. The direct current output by the rectifier 19 supplies an oscillator 22 which pilots a special auto-transformer 23 for raising the voltage. The primary of the transformer 23 has two opposed windings 24 and 25 while the secondary has a

single winding 26.

The voltage obtained across the secondary coil of the transformer 23 is finally raised appropriately by a chain of elements 27, known per se, each of which doubles the input voltage. The required high voltage may thus be obtained at two output terminals 28 and 29 of this circuit 19. Obviously when the cell 10 is applied to an exhaust duct of an internal combustion engine of a motor vehicle, both the transformer 20 and the rectifier 21 are omitted from the circuit 19.

The two terminals 28 and 29 are connected to the anode 12 (Figure 2) and the cathode 13 respectively of the cell 10. This may be excited at a voltage of between 30,000 and 70,000 volts, preferably of the order of 50,000 volts. This voltage generates an electron discharge in which the electrons reach high velocities but less than that of light whereby they are not converted into photons. With a voltage in the range indicated above, the electrons emitted travel in a straight line at a speed of between one fifth and one half the speed of light. With the voltage of 50,000 volts, this velocity is of the order of 100,000 km/sec.

When the cell 10 is excited at this voltage, the negative electrons are emitted through the tips of the elements 31 or the outer edges 16 of the teeth 18, generating

electron beams 30 which are substantially radial and divergent. In the variant of Figure 2, the beams 30 are emitted by the elements 31 so as to create the ionisation zone 11. In the variant of Figures 3 and 4, the beam 30 emitted by the edge 16 of a tooth 18 intersects the beams 30 emitted by the edges 16 of the adjacent teeth 18 whereby a zone of ionisation 11 is created.

The zone 11 constitutes an electron barrier which acts as a molecular filter through which the gases to be purified are forced to pass. Moreover, the helical shape of the edges 16 of the teeth 18 means that beams 30 are generated which are directed in two directions slightly inclined in opposite directions to the plane of the disc 13 (Figure 4) whereby the ionisation zone 11 assumes a corresponding thickness along the path of the gases.

The direct collision of the high-velocity electrons with the complex molecules 5 is such as to break the peripheral electron bonds of the molecules, splitting the molecules into simpler molecules or elementary particles which are no longer polluting and which have picked up a negative electrostatic charge. The collisions with the electrons also transform any simple molecules of chemical elements into non-polluting allotropes or groups of allotropic atoms, that is, into elements which differ in their physical and chemical properties.

The high-velocity electrons also attack the biological cells, for example pollens, bacteria and the like, which generally have a positive electrostatic charge and are neutralised, transforming these into neutral molecules. Hence the cell 10 is also suitable for sterilising and revitalising the air of closed public, industrial or hospital environments.

It is known that negative ions also have a stimulating action on the respiratory tract and the blood circulation. They in fact reduce the hormone serotonin present in the blood of mammals which is the main cause of physical depression. Moreover this hormone stimulates the production of red corpuscles and reduces the cholesterol level in the blood. The interception of the molecules of environmental air with the barrier of electrons thus generates a current of purified air formed by negative ions and free oxygen ions at the outlet from the duct 9. The current, thus purified, may then be likened to mountain air in which the concentration of negative ions may reach values of 10^9 per cubic metre.

The air, thus revitalised, and consequently enriched with oxygen, may be used for the air supply to industrial burners or internal combustion engines, thus increasing the combustion or engine efficiency. Moreover this revitalised air may be used in any other process in which oxygen is required.

It is thus clear that the apparatus described can be used to carry out a purification method including a step in which a gaseous mixture is made to flow along a path, a step in which an electron discharge is generated, the electrons travelling at a velocity such as to create an ionisation zone in the gaseous mixture in transit, and a step in which a series of electron beams 30 is directed so as to intercept the flow of the mixture whereby the peripheral electron bonds of the molecules and/or cells of the polluting substances are broken by collision with the electrons in the free discharge step.

From the above, the advantages of the method and apparatus of the invention over the prior art will be clear. Indeed the method allows gaseous mixtures with a wide range of pollutants to be purified. Since the purification process is purely physical, stoppages due to accumulation of waste which would require periodic intervention or other disposal treatment are not caused. Moreover the apparatus may be designed for a wide range of applications, whether industrial, for means of transport and for closed locations such as hospitals and public buildings.

It is understood that the method and the apparatus described may be modified and improved in various ways without departing from the scope of the claims. For example the anode of the cell may be of prismatic shape.

Moreover the notched disc may be replaced by a series of separate elements of different geometric shapes arranged so as to emit beams of electrons which cross in the zone of interception.

For example, the anode 12 may be a ring shape and/or may be offset with respect to the cathode 13 so that the electron beam forms a sort of umbrella from the cathode 13 to the anode 12. Moreover the cathode 13 may be formed from two or more discs 13 parallel to each other, possibly with different diameters and with different numbers of teeth or other point-like elements so as to increase the thickness and effectiveness of the ionisation zone 11 for the interception of the molecules.

The cathode may also be formed by a brush of metal wires connected to a cylindrical or helical support or support of other shape. Finally, the anode may be formed from a plate of rectangular or other shape and the cathode may be formed from a brush having a shape corresponding to that of the anode with the metal elements directed substantially towards the anode.

CLAIMS

1. A method for purifying a gaseous mixture including molecules and/or cells of toxic or polluting substances, including a step of passing a flow of the gaseous mixture along a path, characterised in that an electron discharge is generated in the path, the electrons travelling at velocities such as to create a zone (11) of ionisation of the mixture, and in that a series of electron beams (30) is directed so as to intercept the flow whereby the peripheral electron bonds of the molecules and/or cells of the said substances are broken by collision with the electrons.

2. A method according to Claim 1, characterised in that the electrons produce non-polluting allotropic elements by the collisions with the molecules.

3. A method according to Claim 1 or Claim 2, characterised in that the electron discharge is obtained with a voltage of between 30,000 and 70,000 volts, the electrons in the discharge being emitted at a velocity of between one fifth and one half the speed of light.

4. A method according to one of the preceding claims, characterised in that at least some of the molecules transformed in this way are separated from the mixture, forming non-polluting waste or residue.

5. A method according to any one of the preceding claims, in which the gaseous mixture comes from industrial productive processes, characterised in that the said substances include molecules of one or more of the following substances: heavy metals, lead, zinc, boron, chlorinated hydrocarbons, arsenic, phosphorus.

6. A method according to any one of Claims 1 to 4, in which the gaseous mixture comprises exhaust gases from combustion plants or internal combustion engines, characterised in that the said substances include molecules of one or more of the following substances: hydrocarbons, carbon, sulphur, carbon monoxides, nitric oxide, carbon dioxide or oxides of sulphur, benzene.

7. A method according to any one of Claims 1 to 4, in which the gaseous mixture comes from a closed animal breeding or plant cultivation environment, characterised in that the said substances include noisome substances and/or pollens.

8. A method according to any one of Claims 1 to 4, in which the gaseous mixture is constituted by vitiated air from closed public, industrial or hospital environments, characterised in that the said substances include dust, carbon dioxide, bacteria or the like, the ions being negative and adapted to revitalise and sterilise the vitiated air.

9. A method according to any one of Claims 1 to 4, characterised in that it is used for enriching the oxygen in the air supply to burners of industrial plants, internal combustion engines or in any other process in which oxygen is required.

10. Purification apparatus for purification by the method of any one of the preceding claims, located in a path along which the mixture is conveyed, characterised in that it includes an ionisation cell (10) for creating a discharge of electrons at velocities such as to create an ionisation zone (11) which intercepts the flow of the mixture, breaking the peripheral electron bonds of the molecules and/or cells of the said substances and freeing non-polluting negative ions.

11. Apparatus according to Claim 10, characterised in that the cell (10) includes an anode (12) and an emitting cathode (13) having a series of elements (18, 31) for ejecting a corresponding series of beams (30) of the electrons, the beams (30) assuming shapes corresponding to the shapes of the anode and the cathode and their mutual positions and being directed so as to form an interception barrier which acts as a filter for the flow.

12. Apparatus according to Claim 11, characterised in that the anode is cylindrical or annular and the emitting cathode comprises at least one disc (13) having a series

of filiform elements (31) in a brush arrangement, the electron beams (30) emitted by the elements being substantially radial.

13. Apparatus according to Claim 11, characterised in that the anode is cylindrical and the cathode includes at least one disc (13) having a series of teeth (18) with edges (16), the electron beam (30) emitted by the edge (16) of each tooth (18) diverging so as partly to intersect the beams (30) emitted by the edges (16) of the adjacent teeth (18).

14. Apparatus according to Claim 13, characterised in that the teeth (17) have a helical shape whereby the beams (30) emerging from the edges (16) of the teeth (18) are inclined in opposite directions to the disc (13), forming an ionisation zone (11) of considerable thickness along the path of the mixture.

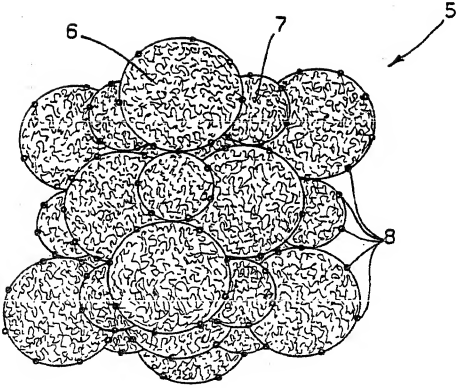
15. Apparatus according to any one of Claims 10 to 14, characterised in that the emitter is excited by an electronic circuit (19) adapted to output a pulsed rectified voltage of between 30,000 and 70,000 volts, the electrons in the discharge being emitted at a velocity of between one tenth and one half the speed of light.

16. Apparatus according to Claim 15, characterised in that the electronic circuit (19) includes an oscillator

(22) supplied with direct current and arranged to pilot a transformer (23) for raising the voltage output by the oscillator (22).

17. Apparatus according to Claim 16, characterised in that the electronic circuit (19) further includes at least one element (27) for doubling the voltage to raise the voltage output by the transformer (23).

Fig. 1



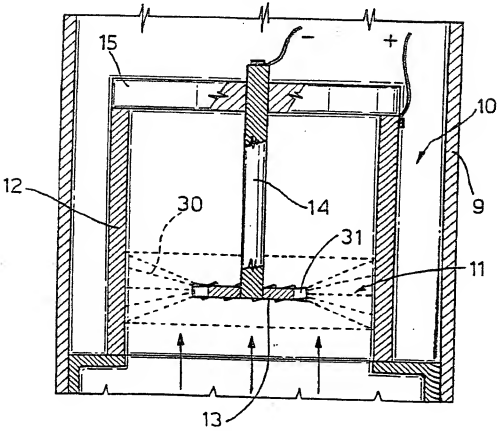


Fig. 2

Fig.3

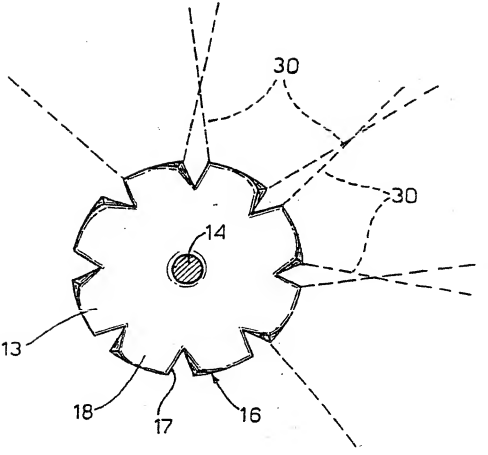
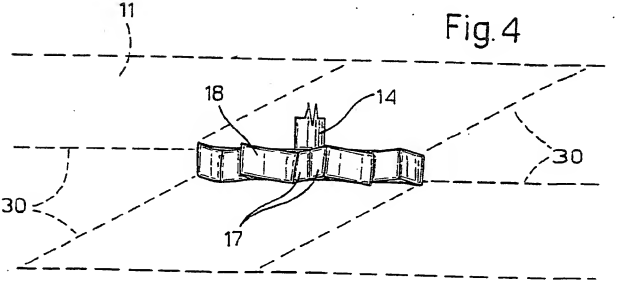


Fig.4



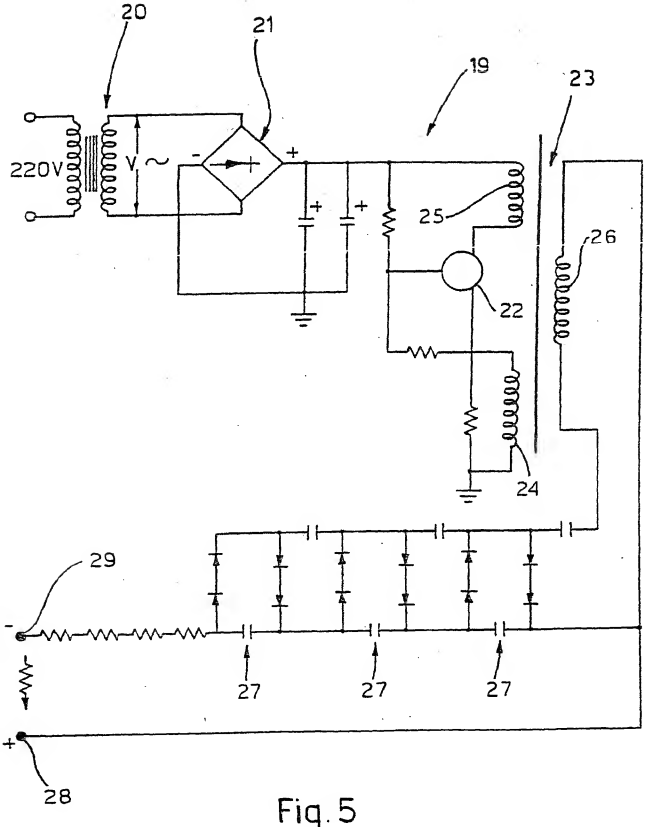


Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B01D53/00

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B. FIELDS SEARCHED

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IPC 6 B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO,A,91 02581 (ADVANCED ENERGY SYSTEMS MARKET) 7 March 1991 see page 5, line 21 - page 9, line 12; figures 1-4	1-8,10, 11,15
X	US,A,3 875 034 (ADAMS LEON M ET AL) 1 April 1975 see column 3, line 3 - line 63; figures 1,3A	1,2,10, 11,13,14
A	EP,B,0 250 866 (NOELL GMBH) 31 January 1990 see column 3, line 40 - column 4, line 47; claim 1	1,2,4,6, 10
A	EP,A,0 579 105 (TOKYO SHIBAURA ELECTRIC CO) 19 January 1994 see page 4, line 35 - line 47; figures 1-3	1,2,6,10

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. nal Application No
PCT/IT 96/00130

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